

1.28: SOLAR/1017-79/06

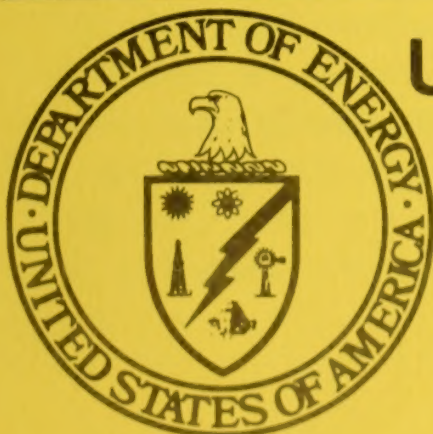
✓
Alep 1215966

SOLAR/1017-79/06

Monthly Performance Report

FACILITIES DEVELOPMENT

JUNE 1979



U.S. Department of Energy

National Solar Heating and
Cooling Demonstration Program

National Solar Data Program

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

MONTHLY PERFORMANCE REPORT
FACILITIES DEVELOPMENT GAS COMPANY

JUNE 1979

I. SYSTEM DESCRIPTION

The Facilities Development Gas Company site is a three-story, multifamily condominium consisting of 31 units in San Diego, California. Solar energy is used for preheating domestic hot water (DHW) for the complex. The solar energy system has an array of flat-plate collectors with a gross area of 520 square feet. The array faces south at an angle of 42 degrees to the horizontal. Potable water is the transfer medium that delivers solar energy from the collector array to storage. Solar energy is stored underground in an insulated 1000-gallon glass-lined tank. Preheated water from the storage tank is supplied, on demand, to 31 conventional 52-gallon DHW tanks. When solar energy is insufficient to satisfy the hot water load, two electrical heating elements, energized separately within the individual DHW tanks, provide auxiliary energy for water heating. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when the water temperature in the collectors is 9°F higher than the temperature of the storage tank. Water is pumped through the collectors and circulates back to storage until the temperature difference is 3°F or less.

Mode 2 - Storage-to-DHW Tank: This mode activates when there is a demand for hot water replenishment by the individual DHW tank. Water from storage circulates by thermosiphoning action through a supply service loop to the individual DHW tanks and returns through a service line to storage. The water in each DHW tank is maintained at an average temperature which is thermostatically controlled. When required, additional energy is supplied by an auxiliary electrical heating element.

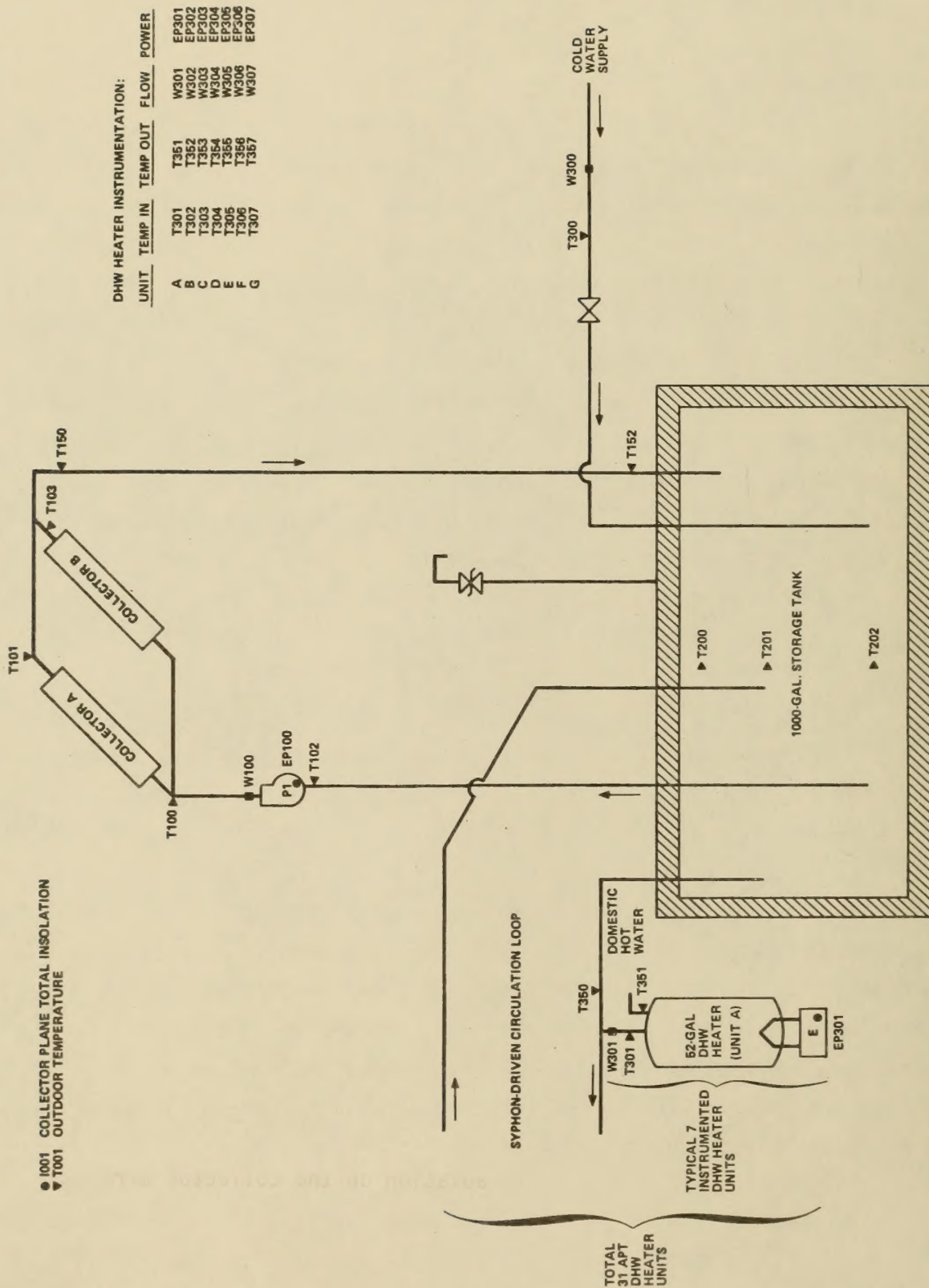


Figure 1. FACILITIES DEVELOPMENT SOLAR ENERGY SYSTEM SCHEMATIC

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied in June and the solar energy system operated continuously during the month. Total solar energy collected was 9.1 million Btu and the total solar energy used was 7.8 million Btu or 9 percent of the collected energy. The stored energy decreased by 0.14 million Btu. Solar energy satisfied 19 percent of the DHW requirements. The solar energy system provided an electrical energy savings of 7.5 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 21.2 million Btu for a daily average of 1360 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during June of 1626 Btu per square foot for a south-facing plane with a tilt of 42 degrees to the horizontal. The average ambient temperature during June was 67°F as compared with the long-term average for June of 66°F.

THERMAL PERFORMANCE

System - During June the solar energy system performed approximately the same as expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as input. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 7.8 million Btu versus an estimated 7.9 million Btu. System total solar fraction was 19 percent and was equal to the estimated solar fraction.

Collector - The total incident solar radiation on the collector array for the month of June was 21.2 million Btu. During the period the collector loop was

operating, the total insolation amounted to 20.2 million Btu. The total collected solar energy for the month of June was 9.1 million Btu, resulting in a collector array efficiency of 43 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 8.8 million Btu. Energy loss during transfer from the collector array to storage was 0.32 million Btu. This loss represented 3 percent of the energy collected. Operating energy required by the collector loop was 0.30 million Btu.

Storage - Solar energy delivered to storage was 8.8 million Btu. There were 7.8 million Btu delivered from storage to the DHW subsystem. Energy loss from storage was 1.1 million Btu. This loss represented 13 percent of the energy delivered to storage. The storage efficiency was 87 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 98°F.

DHW Load - The DHW subsystem consumed 7.8 million Btu of solar energy and 33.2 million Btu of auxiliary electrical energy. The solar fraction of this load was 19 percent. The hot water load was not determined. The DHW subsystem resulted in an electrical energy savings of 7.8 million Btu. A daily average of 979 gallons of DHW was consumed.

OBSERVATIONS

The collected solar energy, the collector loop operating energy, energy delivered to storage, solar energy used, and hot water consumed, were derived from overall solar energy system parameters. Solar fraction was derived from overall energy consumption. The auxiliary electrical energy used (representing the entire building) is extrapolated from the averages of seven instrumented apartment units.

The hot water load and the average value of the hot water temperature supplied to the building were not determined because of inadequate instrumentation.

ENERGY SAVINGS

The solar energy system provided a net electrical energy savings of 7.5 million Btu.

III. ACTION STATUS

Boeing has scheduled instrumentation services in August.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JUNE, 1979

SOLAR/1017-79/06

SITE/SYSTEM DESCRIPTION:

THE FACILITIES DEVELOPMENT SOLAR SYSTEM PROVIDES SERVICE HOT WATER TO 31 UNITS OF A CONDOMINIUM. ALL UNITS HAVE 52 GALLON ELECTRIC WATER HEATERS. SEVEN OF THESE ARE INSTRUMENTED. THE ARRAY OF FLAT-PLATE COLLECTORS PROVIDES 520 SQUARE FEET OF GROSS AREA. STORAGE IS PROVIDED BY A SINGLE 1000 GALLON GLASS LINED TANK, INSULATED AND BURIED.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY

COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE

AVERAGE BUILDING TEMPERATURE

ECSS SOLAR CONVERSION EFFICIENCY

ECSS OPERATING ENERGY

TOTAL SYSTEM OPERATING ENERGY

TOTAL ENERGY CONSUMED

21.212 MILLION BTU
40793 BTU/SQ.FT.
9.114 MILLION BTU
17527 BTU/SQ.FT.
67 DEGREES F
N.A. DEGREES F
0.37
0.295 MILLION BTU
0.295 MILLION BTU
42.590 MILLION BTU

SUBSYSTEM SUMMARY:

LOAD
SOLAR FRACTION
SOLAR ENERGY USED
OPERATING ENERGY
AUX. THERMAL ENERGY
AUX. ELECTRIC FUEL
AUX. FOSSIL FUEL
ELECTRICAL SAVINGS
FOSSIL SAVINGS

HOT WATER
N.A.
N.A.
7.810
N.A.
33.182
33.182
N.A.
7.810
N.A.

HEATING
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.

COOLING
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.

SYSTEM TOTAL
N.A. MILLION BTU
N.A. PERCENT
7.810 MILLION BTU
0.295 MILLION BTU
33.182 MILLION BTU
33.182 MILLION BTU
N.A. MILLION BTU
7.516 MILLION BTU
N.A. MILLION BTU

SYSTEM PERFORMANCE FACTOR:

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,
SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JUNE, 1979
SOLAR/1017-79/06

SITE/SYSTEM DESCRIPTION:

THE FACILITIES DEVELOPMENT SOLAR SYSTEM PROVIDES SERVICE HOT WATER TO 31 UNITS OF A CONDOMINIUM. ALL UNITS HAVE 52 GALLON ELECTRIC WATER HEATERS. SEVEN OF THESE ARE INSTRUMENTED. THE ARRAY OF FLAT-PLATE COLLECTORS PROVIDES 520 SQUARE FEET OF GROSS AREA. STORAGE IS PROVIDED BY A SINGLE 1000 GALLON GLASS LINED TANK, INSULATED AND BURIED.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY

COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE
AVERAGE BUILDING TEMPERATURE
ECSS SOLAR CONVERSION EFFICIENCY
ECSS OPERATING ENERGY
TOTAL SYSTEM OPERATING ENERGY
TOTAL ENERGY CONSUMED

22.379 GIGA JOULES
463242 KJ/SQ.M.
9.615 GIGA JOULES
199031 KJ/SQ.M.
19 DEGREES C
N.A. DEGREES C
0.37
0.311 GIGA JOULES
0.311 GIGA JOULES
44.933 GIGA JOULES

SUBSYSTEM SUMMARY:

LOAD
SOLAR FRACTION USED
SOLAR ENERGY
OPERATING ENERGY
AUX. THERMAL ENG
AUX. ELECTRIC FUEL
AUX. FOSSIL FUEL
ELECTRICAL SAVINGS
FOSSIL SAVINGS

HOT WATER
N.A.
N.A.
8.240
N.A.
35.007
35.007
N.A.
8.240
N.A.

HEATING
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.

COOLING
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.
N.A.

SYSTEM TOTAL
N.A. GIGA JOULES
N.A. PERCENT
8.240 GIGA JOULES
0.311 GIGA JOULES
35.007 GIGA JOULES
35.007 GIGA JOULES
N.A. GIGA JOULES
7.929 GIGA JOULES
N.A. GIGA JOULES

SYSTEM PERFORMANCE FACTOR:

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978.
SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JUNE, 1979

SOLAR/1017-79/06

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.350	64	0.087	N	0.010	N	0.248
2	0.352	64	0.144	O	0.010	T	0.408
3	0.165	63	0.107	T	0.008		0.650
4	0.277	63	0.070		0.010		0.254
5	0.225	63	0.091	A	0.010	A	0.404
6	0.227	62	0.085	P	0.009	P	0.373
7	0.494	64	0.099	P	0.011	P	0.200
8	0.909	65	0.231	L	0.011	L	0.254
9	0.926	71	0.310	I	0.011	I	0.334
10	0.932	79	0.420	C	0.010	C	0.451
11	0.905	79	0.337	A	0.011	A	0.384
12	0.840	77	0.333	B	0.011	B	0.396
13	0.883	75	0.324	L	0.010	L	0.367
14	0.901	69	0.409	E	0.010	E	0.455
15	1.007	67	0.348		0.011		0.346
16	0.847	65	0.416		0.010		0.491
17	0.332	62	0.183		0.007		0.551
18	0.884	63	0.249		0.010		0.282
19	0.873	64	0.298		0.010		0.341
20	0.765	63	0.288		0.009		0.377
21	0.877	64	0.266		0.010		0.303
22	0.862	65	0.291		0.009		0.337
23	0.810	65	0.349		0.008		0.431
24	0.520	64	0.023		0.009		0.044
25	0.753	65	0.460		0.009		0.611
26	0.834	68	0.225		0.011		0.270
27	0.884	69	0.308		0.009		0.349
28	0.857	68	0.363		0.010		0.423
29	0.858	68	0.345		0.011		0.402
30	0.866	69	0.342		0.010		0.395
SUM	21.212	-	7.810	N.A.	0.295	N.A.	-
AVG	0.707	67	0.260	N.A.	0.010	N.A.	0.368
NBS ID	0001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
 & DENOTES NULL DATA.
 N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT COLLECTOR ARRAY PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY SOLAR/1017-79/06
REPORT PERIOD: JUNE, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.350	0.338	0.162	68	0.464
2	0.352	0.336	0.148	65	0.421
3	0.165	0.138	0.060	64	0.366
4	0.277	0.262	0.125	65	0.452
5	0.225	0.211	0.094	64	0.418
6	0.227	0.210	0.087	65	0.382
7	0.494	0.477	0.213	68	0.431
8	0.905	0.876	0.396	70	0.435
9	0.926	0.888	0.393	75	0.424
10	0.932	0.882	0.456	91	0.489
11	0.905	0.879	0.434	90	0.479
12	0.840	0.816	0.369	85	0.440
13	0.883	0.854	0.392	80	0.444
14	0.901	0.862	0.362	73	0.402
15	1.007	0.969	0.446	72	0.443
16	0.847	0.797	0.374	68	0.442
17	0.332	0.254	0.102	64	0.308
18	0.884	0.825	0.408	68	0.462
19	0.873	0.829	0.393	70	0.450
20	0.765	0.725	0.332	68	0.433
21	0.877	0.830	0.368	69	0.420
22	0.862	0.830	0.373	69	0.433
23	0.810	0.758	0.350	69	0.433
24	0.520	0.484	0.141	68	0.271
25	0.753	0.702	0.316	69	0.420
26	0.834	0.811	0.364	73	0.436
27	0.884	0.837	0.369	76	0.418
28	0.857	0.827	0.357	72	0.417
29	0.858	0.835	0.362	72	0.422
30	0.866	0.812	0.366	73	0.422
SUM	21.212	20.158	9.114	-	-
AVG	0.707	0.672	0.304	71	0.430
NBSID	G001		0100		N100

* DENOTES UNAVAILABLE DATA.
 2 DENOTES NULL DATA.
 N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT STORAGE PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JUNE, 1979
SOLAR/1017-79/06

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.161	0.087	-0.299	81	-1.321
2	0.145	0.144	-0.007	84	0.945
3	0.062	0.107	-0.052	80	0.886
4	0.120	0.070	0.031	78	0.840
5	0.089	0.091	-0.009	79	0.926
6	0.084	0.085	-0.012	79	0.873
7	0.207	0.099	0.075	84	0.840
8	0.384	0.231	0.106	97	0.877
9	0.373	0.310	0.040	107	0.938
10	0.439	0.420	-0.005	110	0.945
11	0.420	0.347	0.035	109	0.910
12	0.348	0.333	-0.008	111	0.932
13	0.381	0.324	0.017	110	0.895
14	0.342	0.409	-0.084	110	0.952
15	0.428	0.348	0.019	103	0.858
16	0.359	0.416	-0.056	102	1.004
17	0.105	0.183	-0.111	89	0.691
18	0.400	0.249	0.107	92	0.892
19	0.386	0.298	0.048	100	0.896
20	0.323	0.288	-0.006	101	0.875
21	0.355	0.266	0.027	104	0.822
22	0.355	0.291	0.010	106	0.849
23	0.336	0.349	-0.052	106	0.883
24	0.135	0.023	0.076	101	0.732
25	0.303	0.460	-0.145	102	1.039
26	0.350	0.225	0.096	98	0.918
27	0.354	0.308	0.044	106	0.996
28	0.350	0.363	-0.034	107	0.941
29	0.347	0.345	-0.009	105	0.968
30	0.351	0.342	0.015	106	1.017
SUM	8.790	7.810	-0.142	-	-
AVG	0.293	0.260	-0.005	98	0.872
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT HOT WATER SUBSYSTEM

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JUNE, 1979

SOLAR/1017-79/06

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR FR. OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT SAVINGS MILLION BTU	FOSSIL SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	N	N	0.087	N	1.061	1.061	N	0.087	N	67	N	794
2	O	O	0.144	O	1.183	1.183	O	0.144	O	70	O	1077
3	T	T	0.107	T	1.727	1.727	T	0.107	T	70	T	1146
4	A	A	0.070	A	1.525	1.525	A	0.070	A	69	A	862
5	P	P	0.091	P	1.203	1.203	P	0.091	P	69	P	963
6	P	P	0.085	P	1.425	1.425	P	0.085	P	70	P	931
7	P	P	0.099	P	1.095	1.095	P	0.099	P	70	P	842
8	L	L	0.231	L	1.079	1.079	L	0.231	L	70	L	1010
9	I	I	0.310	I	0.741	0.741	I	0.310	I	70	I	881
10	C	C	0.420	C	0.933	0.933	C	0.420	C	70	C	1055
11	A	A	0.347	A	1.302	1.302	A	0.347	A	70	A	1015
12	B	B	0.333	B	0.865	0.865	B	0.333	B	71	B	896
13	L	L	0.324	L	1.069	1.069	L	0.324	L	71	L	948
14	E	E	0.409	E	1.352	1.352	E	0.409	E	71	E	1051
15			0.348		0.946	0.946		0.348		71		1090
16			0.416		0.982	0.982		0.416		71		1343
17			0.183		1.240	1.240		0.183		71		1066
18			0.249		1.598	1.598		0.249		71		1211
19			0.298		1.030	1.030		0.298		71		1028
20			0.288		1.208	1.208		0.288		71		988
21			0.266		1.074	1.074		0.266		71		891
22			0.291		0.955	0.955		0.291		71		878
23			0.349		0.806	0.806		0.349		71		1001
24			0.023		0.413	0.413		0.023		72		73
25			0.460		1.507	1.507		0.460		72		1520
26			0.225		0.881	0.881		0.225		72		863
27			0.308		1.080	1.080		0.308		72		930
28			0.363		0.991	0.991		0.363		72		1032
29			0.345		0.936	0.936		0.345		73		1042
30			0.342		0.976	0.976		0.342		73		959
SUM	N.A.	-	7.810	N.A.	33.182	33.182	N.A.	7.810	N.A.	-	-	29385
AVG	N.A.	N.A.	0.260	N.A.	1.106	1.106	N.A.	0.260	N.A.	71	N.A.	979
NBS	Q302	N300	Q300	Q303	Q301	Q305	Q306	Q311	Q313	N305	N307	N308

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT ENVIRONMENTAL SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY
REPORT PERIOD: JUNE, 1979

SOLAR/1017-79/06

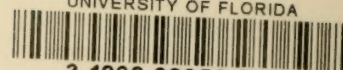
DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	673	N C T	64	68	N O T	N O T	N O T
2	676		64	65			
3	317		63	64			
4	532		63	65			
5	432		63	64			
6	436		62	65			
7	949		64	68			
8	1748		65	70			
9	1780		71	75			
10	1793		79	91			
11	1741		79	90			
12	1616		77	85			
13	1699		75	80			
14	1732		69	73			
15	1936		67	72			
16	1629		65	68			
17	639		62	64			
18	1700		63	68			
19	1678		64	70			
20	1472		63	68			
21	1686		64	69			
22	1658		65	69			
23	1557		65	69			
24	1000		64	68			
25	1448		65	69			
26	1604		68	73			
27	1699		69	76			
28	1648		68	72			
29	1651		68	72			
30	1665		69	73			
SUM	40793	N.A.	-	-	-	-	-
AVG	1360	N.A.	67	71	N.A.	N.A.	N.A.
NBS ID	G001		N113			N115	N114

* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

UNIVERSITY OF FLORIDA



3 1262 09052 5329